

Additive Manufacturing of PEEK and Fiber-Reinforced PEEK for NASA Applications and Custom Medical Devices, Phase I

Completed Technology Project (2018 - 2019)



Project Introduction

There is a significant gap between the properties of materials that are produced using the current 3D printing processes and the properties that are needed to support critical space systems. The polyetherimide/polycarbonate (PEI/PC) composite recently demonstrated on the ISS is a significant step forward in development, however, FDM with PEI/PC represents the current practical limits of AM in space due to the temperature requirements to produce other materials

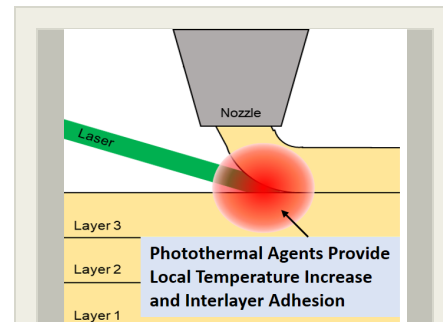
In this Phase I SBIR, AMI, an ISO 13485-Certified (FDA GMP Compliant) Medical Device Developer and Manufacturer, will partner with PSU professors Dr. Michael Hickner of the Center for Innovative Materials Processing through Direct Digital Deposition (CIMP-3D) and Dr. Benjamin Lear, Associate Professor of Chemistry to develop, test, and commercialize a carbon fiber reinforced (CFR) PEEK composite feedstock with improved deposition and strength through focused photothermal polymerization. Polymics Inc, a local company with expertise in compounding PEEK, will produce feedstock ready for 3D print. The project proposed combines three complimentary approaches to achieve additive manufacturing of precision parts with CFR PEEK:

1. Formulation addition of carbon microfibers to PEEK filament feedstock to increase overall strength.
2. Modification of carbon microfibers by impregnating/coating gold nanoparticles to enable photothermally-enhanced bonding to the previous layer.
3. Incorporation of a focused laser beam adjacent to the print head to initiate localized photothermal heating and localized additional heating directly at the extrusion exit point.

Anticipated Benefits

The goal is a feedstock that allows printing of PEEK and CFR PEEK on the ISS, with minimal or no changes to hardware. Additive manufacturing of high performance thermoplastics provides a unique opportunity to enable *in situ* production of: a) large aerospace structures that would be incapable of terrestrial manufacture and delivery b) devices, components or structures on other planetary bodies, and c) temporary, on-demand tools and items capable of being recycled and reused by astronauts.

Additive manufacturing of CFR PEEK to produce: 1) parts with NASA specifications 2) custom external and internal bracing and support components for the medical community and 3) implantable PEEK devices (orthopedics) due to biocompatibility history of PEEK and better match of PEEK to mechanical properties of bone compared to metals. An integral part of the medical effort is being able to conduct critical quality activities like Verification and Validation on parts being printed individually.



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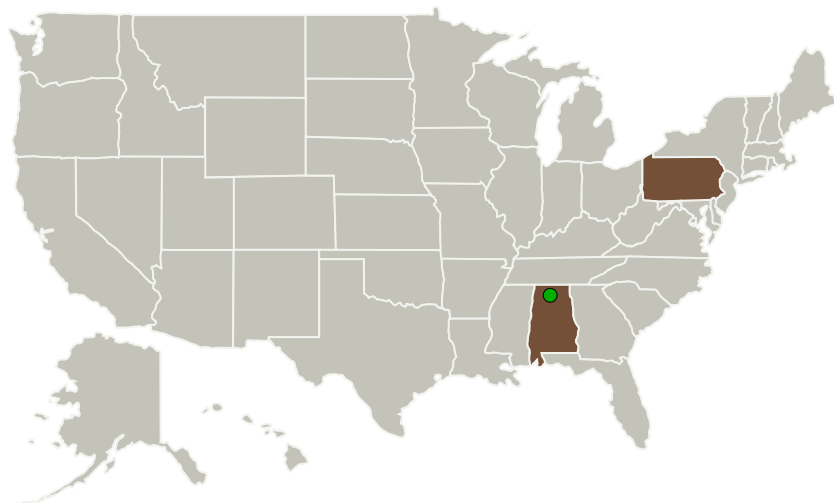
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Actuated Medical, Inc.	Lead Organization	Industry Women-Owned Small Business (WOSB)	Bellefonte, Pennsylvania
● Marshall Space Flight Center (MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations

Alabama	Pennsylvania
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Project Transitions

**July 2018:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Actuated Medical, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

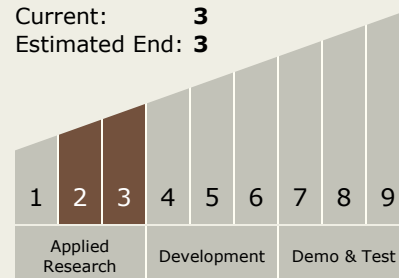
Carlos Torrez

Principal Investigator:

Roger Bagwell

Technology Maturity (TRL)

Start: **2**
 Current: **3**
 Estimated End: **3**



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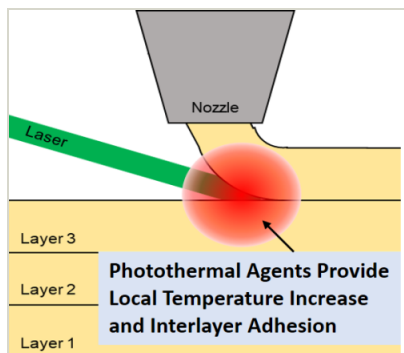


✓ **February 2019:** Closed out

Closeout Documentation:

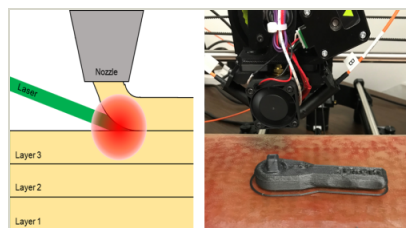
- Final Summary Chart(<https://techport.nasa.gov/file/140903>)

Images



Briefing Chart Image

Additive Manufacturing of PEEK and Fiber-Reinforced PEEK for NASA Applications and Custom Medical Devices, Phase I
(<https://techport.nasa.gov/image/136871>)



Final Summary Chart Image

Additive Manufacturing of PEEK and Fiber-Reinforced PEEK for NASA Applications and Custom Medical Devices, Phase I
(<https://techport.nasa.gov/image/125746>)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - └ TX12.4 Manufacturing
 - └ TX12.4.1 Manufacturing Processes

Target Destination

Earth